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THESIS

PROFITABILITY OF USING FORECASTING TECHNIQUES
IN THE COMMODITIES MARKET

by

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Profitability of Using Forecasting Techniques In The Commodities Market

by

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Box and Jenkins' Autoregressive Integrated Moving Average (ARIMA) forecasts for commodity prices one year into the future are compared to the futures market for accuracy. The ARIMA forecasts were nearly as accurate as the futures prices for predicting commodity prices. On the average, the futures market's Mean Absolute Percentage Error (MAPE) was approximately one percent less than that of the ARIMA models. By incorporating the ARIMA forecasts with the futures prices, it was concluded that a more profitable strategy for purchasing commodities could be obtained. This study showed that an average percentage reduction in purchasing costs of approximately twenty percent resulted when using the policy of buying commodities through futures only when the futures price was less than the ARIMA forecast price.

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I. INTRODUCTION

A. BACKGROUND AND OBJECTIVES

Many organizations in the private as well as the public sectors rely on various commodities as raw materials or inputs to their production processes. Examples of such organizations include processors such as flour millers, manufacturers as in the case of the automobile industry, or even distributors such as wheat exporters. Managers in each of these industries are concerned with the variability of prices in their respective commodity markets. This uncertainty in price fluctuation can lead to equally uncertain profitability. As prices of source materials increase the profit margins of the finished goods will decrease. In most cases, it is not possible for the manufacturer to pass on this entire price increase to the customer. Therefore, it is the concern of the managers in charge of acquisition to reduce the risk involved with procurement costs of commodities. The purpose of this study will be to determine if systematic methods are available to the managers which can effectively reduce the risk of unfavorable price movements and improve profit margins.

B. THE RESEARCH QUESTIONS

This study will attempt to answer three questions concerning the management of costs in commodity procurement.

The first question of concern is: "can time series analysis, in particular Box-Jenkins methodology, be used to accurately forecast intermediate future commodity prices?" Intermediate future being up to one year in the future. The second question relates to whether systematic forecasting models can be developed to predict future prices more accurately than the futures market, which is a reflection of the market's forecast. Finally, the study will attempt to discover if the Box-Jenkins forecasting method can result in a net savings or profit when compared to futures contract prices.

C. THE SCOPE OF THE RESEARCH

This research will center around commodities that are actively traded in the futures market. The commodities examined will include copper, corn, cotton, heating oil, hogs, oats, soybeans, and wheat. Historical data will be accumulated and used to build forecast models which will then predict prices for up to one year in the future. Forecasts will be made for each of the years 1982, 1983 and 1984. In order to thoroughly investigate the nature of commodity futures contract prices, it would be desirable to analyze all commodities traded in the futures market and over a much longer time period. However, the techniques involved with the use of Box-Jenkins methodology in time series analysis and model building are a time consuming process. As such a limitation as to the number of commodities and the time period analyzed had to be imposed. In addition, only commodities which are traded in the futures market could be used, since futures prices will be used as the comparison index. The eight commodities over the three years mentioned should present a representative sample from which reasonable conclusions can be obtained.

D. LITERATURE REVIEW AND METHODOLOGY

There have been many studies attempting to determine whether commodities markets are inefficient or efficient. This study was based on the hypothesis that the markets are inefficient. The literature review, outlined in Chapter II, shows that several time series analysis techniques have demonstrated statistically that the markets may indeed be inefficient. Therefore, one of the major objectives of this study is to examine whether or not a systematic forecasting method can be developed to take advantage of market inefficiency.

The methodology used for time-series analysis in this study was that developed by Box and Jenkins. This method applies autoregressive and moving averages to develop a model used in forecasting futures prices. Chapter III illustrates the methodology employed by Box and Jenkins.

An initial study as to whether or not intermediate term forecasting could accurately forecast commodity prices served as the motivation to this study and demonstrated that a degree of success in forecasting prices did exist [Ref. 1].

E. SUMMARY OF FINDINGS

The results of this study revealed that the Box-Jenkins models could, on the average, forecast commodity prices with an absolute error of approximately 10 percent. It was also found that, on the average, forecasts using the models were only slightly less accurate than the futures market forecasts. The difference was of the order of one percent.

The primary purpose of this study was to determine if a more profitable position could be realized by incorporating the forecasting models in the decision process of purchasing commodities. An effective buying policy was established as follows:

1) If model forecasts of prices were less than the futures price, then forego purchasing futures and buy on the cash market.

2) If futures prices were less than the model forecasts, then buy futures.

The conclusion was that, by following this policy, a significant amount of savings could be realized over those possible by relying on the market's forecast and trading exclusively in futures contracts.

II. THE NATURE OF THE COMMODITIES MARKET

A. FUTURES TRADING

The commodities futures market grew out of the need to match supply with demand. Before the existence of the futures market, suppliers would bring their harvest to the market place and attempt to sell the entire stock. Because of the seasonal nature of most crops, this resulted in an excess supply and consumers obtained goods with the lowest prices. In addition, this excess supply resulted in unsold stock being literally discarded into the streets. In 1848, the Chicago Board of Trade was formed to try and alleviate this problem.

The nature of the futures market is to provide producers and consumers of the various commodities, a central trading place where supply and demand forces can establish market efficiency. The futures contract is an agreement to either buy or sell an established quantity of a commodity, at a future date, for the price of that contract. Because of the large volume of contracts traded, the following rules were established to ensure responsible trading:

1) The commodity had to be easily graded and meet quality standards which were established and regularly inspected.

2) Payment had to be made when the commodity was delivered.

3) Prices had to be easily accessible and available for all traders.

4) Financial responsibility was required of all buyers and sellers.

5) A large volume of traders was necessary to ensure a continuous opportunity for trade. [Ref. 2]

The commodities futures market has proven to be a highly speculative market. Usually less than 2 percent of the futures transactions actually results in a commodity delivery [Ref. 3]. The majority of these transactions are taken up by hedgers and speculators.

B. HEDGING IN THE COMMODITIES MARKET

Hedging is a method used by producers, processors, and distributors, to reduce their financial risk due to price fluctuations. It involves the purchasing and selling of futures contracts to protect against price changes. Working expanded this to include other reasons for hedging:

1) It facilitates buying and selling decisions. When hedging is practiced systematically, there is need only to consider whether the price at which a particular purchase or sale can be made is favorable to other current prices; there is no need to consider also whether the absolute level of the price is favorable.

2) It gives greater freedom for business action. . . . the freedom gained is to make a sale or purchase that would not otherwise be possible at what is judged a favorable price level, as when a cotton grower sells futures in advance of harvest, or a textile mill buys futures because cotton prices are judged to be favorable, but the desired qualitites of cotton cannot be bought immediately in the spot market.

3) It gives a reliable basis for conducting storage of commodity surpluses. The warehousing of surplus commodity stocks is a very uncertain and hazardous business when based on trying to judge when price is favorable for storage; hedging allows operation on the basis simply of judgement that the spot price is low in relation to a futures price.

4) Hedging reduces business risks. There is usually reduction of risk when hedging is done for any of the previous three reasons (though often not under the second reason), but any curtailment of risk may be only an incidental advantage gained, not a primary or even a very important incentive to hedging [Ref. 4].

Hedging is taking an opposite position in the futures market of that of one's own position in the cash or "spot" market. The reason for this is that futures prices usually follow parallel movement to that of the cash prices. In addition, since a commodity can be delivered against a futures contract, it tends to keep a close relationship between cash and futures prices. If not, as the month of delivery begins a difference between cash and futures prices would encourage arbitrage and traders would buy in low markets and sell in high. The difference between the cash price and the futures price is known as the "basis".

There are two types of hedges, the short (selling) hedge and the long (buying) hedge. The short hedge is used by the producer of the commodity while the long hedge is typically used by the consumer or processor, thus protecting each of their respective prices.

The following is an example of a selling hedge: In March, a grower of wheat decides to offset his expected yield in June by selling a sufficient number of July wheat futures contracts. The cash price he expects to obtain per bushel in June is $3.50. The July futures are selling for $3.65/bu in March. This example will assume that cash and futures prices move in equal segments, or what is known as the perfect hedge. Rarely, if ever, does a perfect hedge occur. In June, the cash price of wheat is $3.35/bu and the July futures is at $3.50/bu. There has been a 15 cent reduction in the expected cash price, however, it has been offset by a 15 cents/bu gain in the futures market because of the short hedge. Thus the farmer has grossed his expected price of $3.50/bu by selling his wheat in the cash market for $3.35/bu and gaining 15 cents/bu in the futures market by buying back his future contracts. Figure 2.1 shows this transaction. [Ref. 5]

A buying hedge or long hedge would be similar except that it will be in the opposite direction, so that the processor realizes the benefits.

C. SPECULATING IN THE COMMODITIES MARKET

Speculation in the commodities market has been referred to as anything from gambling to a destructive force in price efficiency, to that of an absolute necessity for market efficiency. The speculator enters the futures market in hopes of making a profit on his or her expectations of price movements.

CASH	FUTURES	BASIS
March 15 Objective is $3.50/bu	Sells July wheat Futures at $3.65/bu	$0.15 under
June 15 Sells wheat at $3.35/bu	Buys July wheat Futures at $3.50/bu	$0.15 under
Result $0.15/bu less than price objective	Gain $0.15/bu	Change $0.00

Cash price received for wheat	$3.35/bu
Gain on futures contracts	.15/bu
Gross Price Received	$3.50/bu

Figure 2.1 Example of a Perfect Hedge

One of the early theories proposed by John Maynard Keynes was that of "normal backwardation" where he asserts that hedgers pay a risk premium to relieve themselves of price risk, while speculators only enter the market because they expect to collect that premium [Ref. 6]. However, there have been many theories which run contrary to this or go beyond that simple explanation. Many of these will be addressed under market efficiency.

D. PRICE FORECASTING IN THE COMMODITIES MARKET

The price of a commodity futures contract is a reflection of the market's participants' expectation of price movements. There are basically two approaches to forecasting commodities prices, the fundamental approach and the technical approach.

1. <u>The Fundamental Approach</u>

The fundamental analyst concludes that the price of a commodity is a result of the forces of supply and demand for that commodity and that ultimately the price is the equilibrium point between those factors.

The sources of supply for a commodity are production and inventory if the commodity is storable. Most fundamentalists do not believe that any form of technical analysis would lend itself to determining levels of supply. However, assuming that supply was a key factor in determining price, perhaps a systematic supply variability would be reflected in a time series analysis of commodity prices. Examples of possible systematic supply variability include:

a) Variability in rainfall and other production conditions. The commodity could be an agricultural product grown in a region of known and predictable rainfall. In addition, a specified amount of land may be available which limits production.

b) Variability in prices of inputs. If prices of inputs to production vary systematically, then it is expected that levels of supply could also vary accordingly.

c) Variability in supply due to a variation in the price of outputs. An illustration of this is the cobweb. A high price of a commodity today leads to increased production next year which then leads to lower prices which again leads to lower supply the next year and again higher prices.

It can also be observed that demand may show signs of systematic variability, for example:

a) Income of consumers may vary over a trade cycle and result in variations of the quantity of a commodity demanded.

b) Variability in other commodity prices in a systematic manner could cause a variability in demand if they are close substitutes for one another. [Ref. 7]

Thus, a fundamentalist may be able to predict future prices by analyzing historical data if supply and demand factors were systematically reflected in those past prices.

2. The Technical Approach

The technical approach analyzes the market itself rather than the external factors affecting supply and demand. This approach assumes that conclusions about future prices can be obtained by statistically analyzing past prices. The technician does not believe in the random walk theory of commodity prices but rather that prices are predictable. Because there are so many fundamental elements that come into play at one time, it is possible that an important one could be overlooked or improperly evaluated, thus limiting the accuracy of the fundamental approach. [Ref. 8]

Technicians use numerous methods for analyzing historical prices, from charts to computers. Two of their fundamental theories are that markets move in trends and that trends tend to persist. It is this persistence of existing trends which serves as an argument against the Random Walk Theory [Ref. 9]. This thesis uses the technical approach to determine the accuracy of the Box-Jenkins time series analysis in forecasting commodity prices.

E. MARKET EFFICIENCY

A market is considered efficient when its prices fully reflect all available information. The conditions that must exist in order to have an efficient market are homogeneous products, with a large number of traders with no one trader able to manipulate prices and complete information for all participants [Ref. 10]. The theory of the efficient market is described in three forms, strong efficiency, semistrong efficiency, and weak efficieny [Ref. 11].

1. The Strong Efficient Market

The strong efficient market assumes that prices reflect all available information that is known to anyone, including insiders. For this theory to exist in the commodities market would require that futures contract prices precisely forecast future cash prices. Since all available supply and demand information would be known to all traders, an equilibrium price would exist and would only change as information concerning supply and demand factors changed.

Many studies have been performed to determine whether futures accurately forecasted cash prices. Labys and Granger applied cross-spectral analysis to futures and cash prices over a fifteen year period and concluded that:

"While the results express a tendency for the correlations between cash and futures and near and more distant futures prices to follow a definite time pattern over the long-run frequencies, the same results do not provide evidence that futures prices are capable of predicting cash prices." [Ref. 12]

2. The Semistrong Efficient Market

The semistrong efficient market occurs when the market prices reflect all publicly available information. While most recent literature supports rejection of the strong market efficiency, some are in support of the semistrong efficient market theory. Conklin studied the correlation between publicly available information and price changes in the grain export market. He concluded that the hypothesis of semistrong form pricing efficiency could not be rejected for grain exports [Ref. 13]. However, there are studies which tend to challenge the semistrong efficiency theory, as an example:

> Newbery and Stiglitz found that even when individuals have fully absorbed all the information available on the market and used it efficiently in their production decisions the market equilibrium was not Pareto efficient. [Ref. 14]

3. The Weak Efficient Market

The weak efficient market assumes that prices are based on all information contained in past prices. The weak efficiency theory evolved because of a preponderance of evidence that commodity and stock prices changed in a random fashion. This market behavior became known as the random walk theory. Assuming that a market was efficient, then prices should reflect all available information. Since market information tended to be generated in a random nature this implied that prices would also move in a random pattern. Tomek and Querin studied this random process and concluded that overall, futures prices displayed randomness, however "systematic components" during finite periods displayed trends that could be profitably exploited. [Ref. 15]

Numerous studies have been performed to establish whether this random walk theory prevails, supporting the theory of an efficient market. Many have found significant dependence and trends, which, if utilized, could result in more profit than a buy-and-hold policy. The following are a selection of those studies:

> Brinegar found a statistically significant tendency of positive serial correlation when analyzing the prices of wheat, corn and rye over a four to sixteen week period. In addition, he discovered a slight "reaction tendency" or negative correlation during shorter intervals. [Ref. 16]

> In his study of serial correlation, Houthakker, used a stop-loss procedure to determine if a greater profit could be realized over that of no stops at all. His study focused on the theory that a price trend would be indicated if a stop-loss percentage could be discovered that resulted in increased average profits. He cites some evidence of a nonrandomness. [Ref. 17]

> Houthakker also did a study analyzing the ability of speculators to forecast cotton and grain commodity prices. He concluded that both in the long and short run, large speculators displayed definite evidence of forecasting ability. [Ref. 18]

> Smidt analyzed daily soybean prices over a 10-year period and provides evidence of the presence of positive and negative serial correlation. [Ref. 19]

By using a filter technique on stock prices, Alexander concluded that price changes in stock price averages tended to be followed by a subsequent change in the same direction. [Ref. 20]

Cootner demonstrated another technique which proved more profitable than the buy-and-hold theory. His rule was to buy stock when the price exceeded a 40 day moving average by some percentage and sell when it dipped below by some percentage. This was applied to 45 stocks on the New York Stock Exchange. [Ref. 21]

A study by Stevenson and Bear using varying filters on corn and soybeans over a 12-year period, demonstrated some examples of increased profitability over that of a buy-and-hold strategy. They established three different techniques with varying results, however evidence of nonrandomness was present in all three techniques. [Ref. 22]

There have been numerous other studies to determine whether or not the commodities market is an efficient market (e.g., see also [Ref. 23], [Ref. 24], [Ref. 25]). The majority of which tend to support the theory that the commodities market is inefficient.

The purpose of this thesis is to determine whether Box-Jenkins forecasting of commodity prices, based on analysis of past prices, is more accurate than the markets forecast using futures, which, if proven, will support the notion that the commodities market is an inefficient one.

III. BOX-JENKINS METHOD OF FORECASTING

There are many quantitative methods of model building and forecasting used in business management and science today. With the development of the computer and its availability, these techniques have become easier, faster, and more accurate to use.

These forecasting methods can be categorized in two groups, causal and time series. The causal method attempts to identify independent variables and their relationship to the variable of interest, the dependent variable. Changes in the independent variables are then expected to cause changes in the dependent variable. By finding the proper relationship of the independent to dependent variables, a model can then be built which will be used to forecast dependent variables, given an input of the independent variables.

One of the drawbacks to the causal method is that in some cases it is very difficult, if not impossible, to find independent variables that can entirely explain the occurrences of the dependent variable. In addition, even if an accurate model can be formulated, it is only as good as the ability to predict the values of the future independent variables. This brings us to the second type of model, the time series model.

A. TIME SERIES ANALYSIS

Time series models attempt to forecast the future by analyzing the past. Time series analysis observes historical data and attempts to derive some process which will explain those occurences and predict future values. Most time series analysis techniques attempt to identify the patterns which typically exist. These include long-term trend, seasonal, cyclical, and random variations.

The Box-Jenkins method can be identified as a stochastic mathematical model. A stochastic or probability model is one that attempts to calculate the probability of a future value lying between two specified limits. Therefore, a time series observation can be thought of as a series generated by a stochastic process in which an infinite number of possible series could have resulted [Ref. 26].

B. ITERATIVE APPROACH

The Box-Jenkins approach is regarded as one of the best methods of time series analysis because of its iterative nature to determine, statistically, the best fit. This iterative approach can be classified in four basic stages:

1) The first step is to postulate a general class of models based on theory and experience. Since this usually results in a rather extensive list the following step is necessary to reduce this to a more manageable list.

2) Identify the forecast model to be tentatively entertained. The objective here is to apply autocorrelation and partial-autocorrelation techniques

to identify the best match between observed and theoretical results. In addition the parsimonious principle of choosing the models with the least number of parameters that suitably reflects results is applied.

3) Estimate the parameters of the tentatively entertained model by fitting it to the historical data. Here iterative methods are used to estimate the coefficients which minimize the sum of squared residual errors.

4) The last stage is that of diagnostic checking to determine if a lack of fit occurred and if so what was the possible cause. By applying the autocorrelation function to the residual errors and determining their randomness, the adequacy of the fit can be determined. If the model is found inadequate then the process is repeated until an adequate model has been found. Then this model is used to forecast until it is necessary to reevaluate.

Figure 3.1 shows the stages of this iterative approach [Ref. 27].

C. AUTOCORRELATION

The autocorrelation function of a time series is used to identify any association (mutual dependence) between values in the same time series. Thus, it is useful in trying to determine if values in a time series are a result of previous values in that same series. Randomly generated data should therefore demonstrate zero autocorrelation, while seasonal or cyclical data should demonstrate a high autocorrelation. Correlograms which are a plot of the autocorrelation function versus the log period are used to identify what level, if any, of autocorrelation exists.

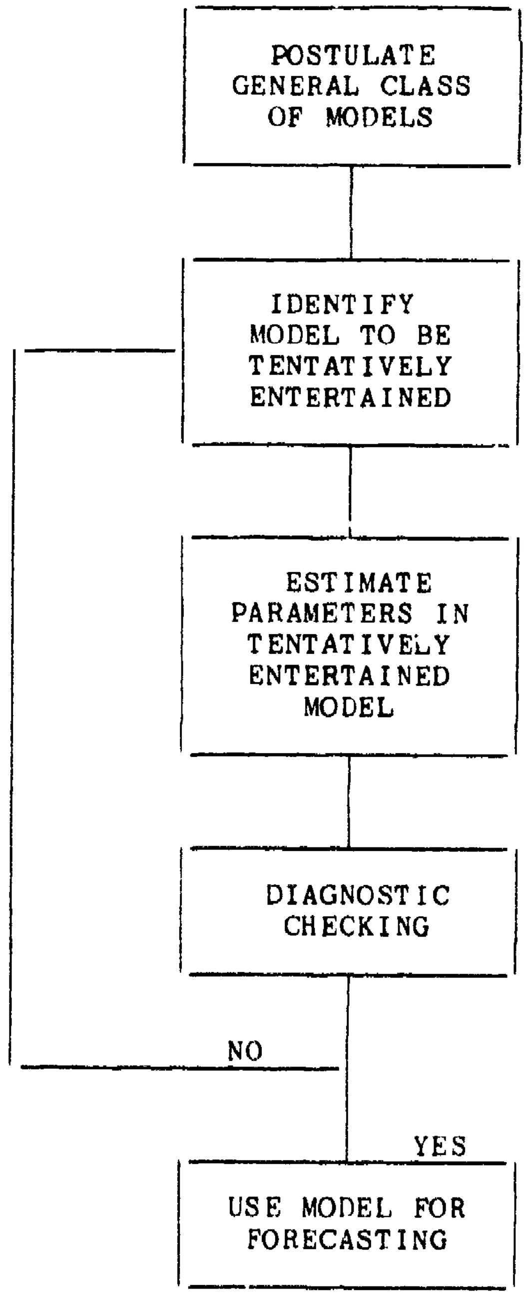

Figure 3.1 Iterative Modeling Approach

Another function which is useful for identifying models is the partial autocorrelation. The partial autocorrelation function attempts to relate the strength of the various lag periods. Box and Jenkins express the relationship as follows:

> For an autoregressive process of order p, the partial autocorrelation function ϕ_{kk} will be nonzero for k less than or equal to p and zero for k greater than p. In other words, the partial autocorrelation function of a p^{th} order autoregressive process has a cutoff after lag p. [Ref. 28]

D. MODEL TYPES

1. Stationary

A time series is considered stationary when it remains in equilibrium around a mean level μ and a variance of σ^2. A non-stationary series is one that does not meet these conditions, in otherwords, a trend is usually present. In order to apply the Box-Jenkins technique a time series must be stationary. However, in analyzing typical economic, business, industrial and scientific time series it is found that many of them more closely represent a nonstationary series. When a nonstationary time series is encountered, it is necessary to convert it to a stationary series by a technique called differencing. Differencing (∇) creates a new time series from the previous series by taking the difference between two consecutive values and then repeating:

$$\nabla x_t = x_t - x_{t-1}$$

To obtain stationarity more than one differencing may be required. The order of differencing may be required. The order of differencing is denoted as d in the ARIMA nomenclature. Table I shows an example of a differenced series and how it eliminates the trend from the initial series:

TABLE I

ELIMINATION OF TREND IN DIFFERENCED SERIES

x_t	∇x_t	$\nabla^2 x_t$
7	--	--
8	1	--
11	3	2
10	-1	-4
14	4	5
16	2	-2
19	3	1
24	5	2
30	6	1
33	3	-3
36	3	0

There are essentially two types of stationary models used by Box and Jenkins. These are the autoregressive and the moving average models. In addition, a combination of the two can exist and is called the mixed autoregressive/ moving average model.

2. Autoregressive Model

Autoregressive models, represented as AR(p), relate the current value of a series Z_t to the previous values and an unknown random (white noise) term e_t. For convenience we will let $\dot{z}_t = Z_t - \mu$, therefore the equation for an autoregressive model of the p^{th} order, AR(p), can be represented by:

$$\dot{z}_t = \phi_1\dot{z}_{t-1} + \phi_2\dot{z}_{t-2} + \ldots + \phi_p\dot{z}_{t-p} + e_t$$

An example of an AR(2) model would be:

$$\dot{z}_t = \phi_1\dot{z}_{t-1} + \phi_2\dot{z}_{t-2} + e_t$$

and to ensure stationarity the values of the coefficients must be:

$$\phi_2 + \phi_1 < 1$$

$$\phi_2 - \phi_1 < 1$$

$$-1 < \phi_2 < 1$$

3. Moving Average Model

In the moving average model, represented as MA(q), the current value of a time series can be thought of as the current noise or shock e_t and a weighted value of previous noise levels. Again allowing, $\dot{Z}_t = Z_t - \mu$, the equation of a moving average model of order q, MA(q), can be represented by:

$$\dot{Z}_t = e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2} - \cdot \cdot \cdot - \theta_q e_{t-q}$$

An example of a second order moving average model would be, MA(2):

$$\dot{Z}_t = e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2}$$

where again in order to meet stationarity requirements:

$$\theta_2 + \theta_1 < 1$$

$$\theta_2 - \theta_1 < 1$$

$$-1 < \theta_2 < 1$$

For both autoregressive and moving average models of the first order, in order to ensure linearity $|\phi_1| < 1$ and $|\theta_1| < 1$.

4. Mixed Autoregressive/Moving Average Models

Box and Jenkins have noted that in order to arrive at a model with fewer total parameters (parsimony) it may be necessary to combine both AR(p) and MA(q) models into one model expressed as ARMA(p,q) [Ref. 29]. In other words, a model that shows future values of a time series being dependent upon previous series values as well as previous errors between actual and predicted values. The equation for an ARMA(p,q) model can be represented by:

$$\dot{z}_t = \phi_1 \dot{z}_{t-1} + \phi_2 \dot{z}_{t-2} + \cdots + \phi_p \dot{z}_{t-p} + e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2} - \cdots - \theta_q e_{t-q}$$

An example of an ARMA(1,2) model would be:

$$\dot{z}_t = \phi_1 \dot{z}_{t-1} + e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2}$$

It should be noted that an AR(p) model can be written as ARMA(p,0) and an MA(q) model can be written as ARMA(0,q). It was mentioned previously that differencing may be necessary in order to obtain stationarity. If differencing is performed then the ARMA model results in an integrated autoregressive/moving average model or ARIMA. If d is the order of differencing, then this model would be written as ARIMA(p,d,q).

Should a time series exhibit seasonal characteristics, then a seasonal differencing can be performed and the model would be written as ARIMA(p,d,q) $x(P,D,Q)_S$ where S is the period of seasonality, P and Q represent the number of seasonal autoregressive and moving average parameters respectfully and D is the order of seasonal differencing [Ref. 30].

E. METHOD OF SELECTING APPROPRIATE MODEL

1. Identification

Using the iterative process mentioned previously, the first step is to identify a tentative model. By using the autocorrelation and partial autocorrelation functions the model can be identified.

Figure 3.2 shows typical autocorrelation and partial autocorrelation correlograms for various models.

Table II shows the duality relationship between autocorrelation and partial autocorrelation for the various models [Refs. 31 and 32].

2. Parameter Estimation

Once a time series has been tentatively identified the parameters must be estimated. This is usually accomplished by choosing values which result in the minimum sum of the squared errors between the model and the actual values or least squares approach. Here is where a computer can expedite the searching process.

TABLE II

DUALITY RELATIONSHIP OF CORRELOGRAMS

	Autoregressive Process	Moving Average Process	Mixed ARMA Process
Autocorrelation Function	Infinite and tails off; composed of damped exponentials and/or damped sine waves	Finite; there will be q non-zero autocorrelations	Infinite and tails off; composed of damped exponentials and/or damped sine waves after the first q-p lags
Partial Autocorrelation Function	Finite; there will be p non-zero partial autocorrelations	Infinite and tails off; dominated by damped exponentials and/or sine waves	Infinite and tails off; composed of damped exponentials and/or sine waves after the first p-q lags.

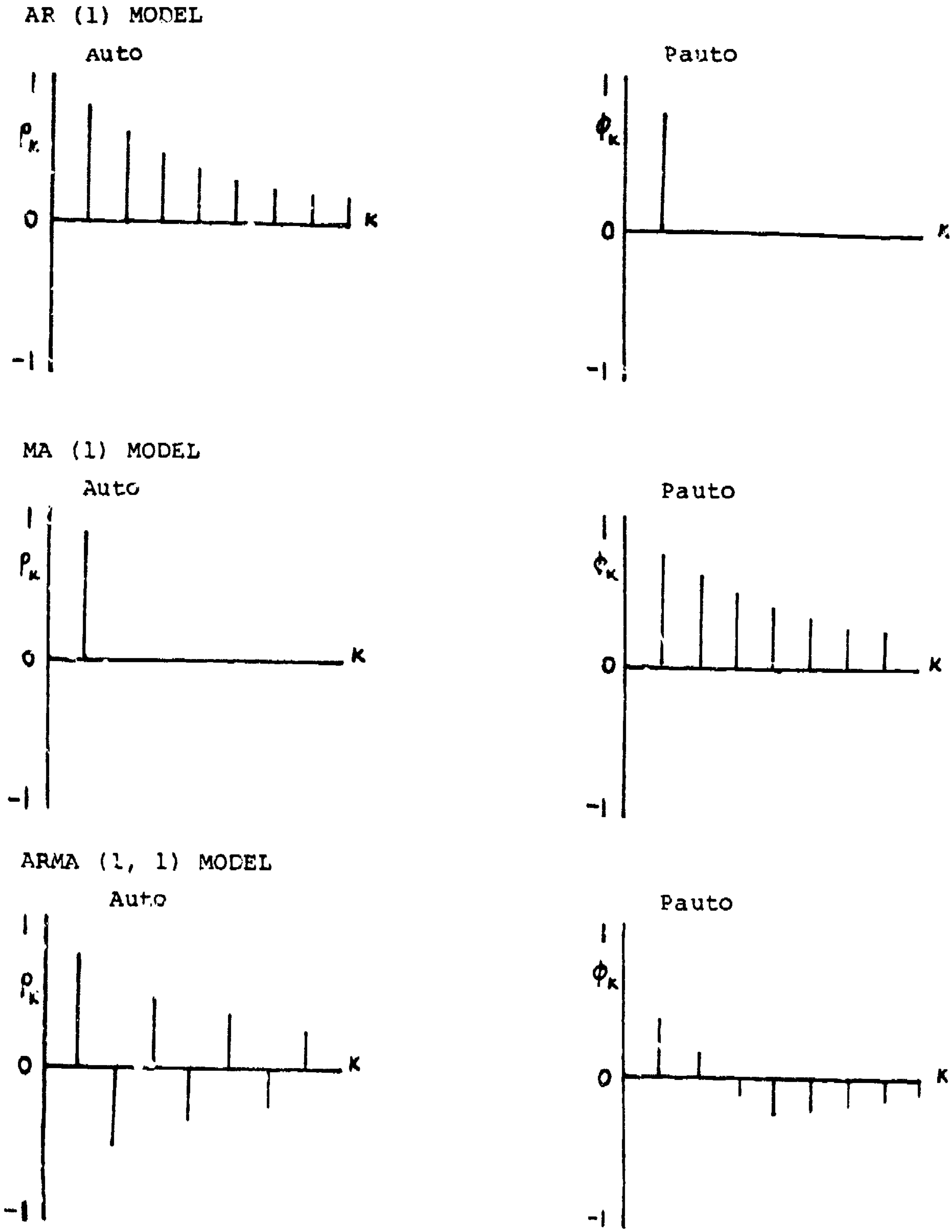

Figure 3.2 Autocorrelation and Partial Autocorrelation Correlograms

3. Diagnostic Checking of the Models

Now that the model has been tentatively identified and parameters established, the next step is to determine if this model is optimal. This is accomplished by analyzing the residuals for randomness. The autocorrelation and partial autocorrelation functions applied to the residuals will determine if the errors are random. If this test fails then the procedure must be reinitiated until an appropriate model is formulated. Once a model is formulated it can then be used to forecast future values of the time series.

IV. COMPARISON OF MODEL AND MARKET FORECASTS

The Box-Jenkins method was used to develop models to forecast commodity prices for eight different commodities during the years 1982 through 1984. The results of these forecasts and the futures prices or market forecast are presented in the tables of Appendix A.

A. DATA SOURCES AND MODEL DEVELOPMENT

The commodity prices used in this study were the average monthly prices obtained from the Commodity Year Book published by the Commodity Research Bureau, Inc. [Ref. 33]. For the commodity prices in 1984 not published to date in the Commodity Year Book, the monthly price was obtained by averaging the daily commodity prices published in the Wall Street Journal. To develop the forecasting models, prices for the eight commodities, which included copper, corn, cotton, No. 2 heating oil, hogs, oats, soybeans and wheat, were collected from 1971 to 1982 with the exception of heating oil which started with 1973. In all cases, at least 100 data entries were used to build the models to predict 1982 commodity prices. When building the forecast models for 1983, the monthly prices for 1982 were added to the data base to update the model. The same procedure was used to update the model for 1984 forecasting. The models were used to forecast monthly prices for the next calendar year. For comparison purposes, the data for market forecasts consisted of commodity futures prices collected on the last day of the calendar year preceding the forecast year. Since future contracts are not traded for every month, only those contract months which are traded can be used for comparison. These futures prices represent the market's forecast of commodity prices during the appropriate months.

The technique used in forecasting was exclusively the ARIMA time series analysis method developed by Box and Jenkins. The model building and forecasting was performed on an International Business Machines (IBM) Model 3033 Series mainframe computer using the MINITAB statistical analysis software package and MINITAB Reference Manual [Ref. 34].

B. RESULTS

Appendix A shows all the forecast results as well as the futures prices, actual prices and absolute percentage errors between actual prices and both the model forecasts and futures. The Absolute Percentage Error (APE) is the absolute value of the percentage difference of either the model forecast or futures price from that of the actual commodity price. Another criteria used in evaluating the results is the Mean Absolute Percentage Error or MAPE, which is the average value of the APE values during the period.

MAPE values are computed for annual as well as quarterly values. In addition, since the purpose of this thesis is to compare model forecasts to market forecasts, only months that futures are traded are used for computing APE values.

Table III lists the MAPE figures by comparing model forecasting and actual prices of eight commodities for each of the three years analyzed, while Table IV lists MAPE figures from the comparison of futures prices and actual prices. At the bottom of each table are the average values of each column. For example, the average yearly MAPE of all 24 commodities using the forecast models is 10.96 percent, and that of the futures market is 9.95 percent.

There are some things to be noticed with these two tables. First is the fact that an increasing trend of forecast errors exist as you move from the first through the fourth quarters. In other words, the accuracy of the model and market forecasts declines over time. As we would expect, both forecasts are most accurate in the immediate future and deteriorate for more distant forecasts. The results also show that the futures market and model forecast values are equally accurate. When a TWOSAMPLE T statistical test was performed the results revealed that this difference of 1.01 percent was insignificant. Thus supporting the null hypothesis that the MAPE's for the futures and the models forecast are equal. This minimal

TABLE III

MEAN ABSOLUTE PERCENTAGE ERRORS (MAPE) FOR MODEL FORECASTS

	Entire Year	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
1982 Copper	06.72	02.95	02.43	12.74	10.28
1983 Copper	08.62	09.32	13.47	07.35	04.19
1984 Copper	06.75	03.36	02.18	11.70	11.56
1982 Corn	06.60	07.27	11.33	06.31	01.79
1983 Corn	23.16	15.83	19.07	27.69	25.54
1984 Corn	10.79	04.89	02.95	07.86	30.41
1982 Cotton	07.42	06.46	09.80	12.67	04.07
1983 Cotton	12.97	08.44	08.70	12.46	17.62
1984 Cotton	10.81	00.78	06.38	12.66	17.12
1982 Heating Oil	05.85	01.56	12.09	05.04	04.12
1983 Heating Oil	19.44	14.31	25.83	19.94	17.68
1984 Heating Oil	10.56	05.31	07.57	14.32	16.30
1982 Hogs	25.23	20.56	29.76	25.93	22.35
1983 Hogs	07.78	03.18	08.06	09.48	08.08
1984 Hogs	06.00	14.73	04.15	03.02	06.48
1982 Oats	15.68	04.57	04.87	22.97	23.04
1983 Oats	07.49	01.72	03.04	09.08	14.54
1984 Oats	06.30	04.58	00.29	09.46	07.72
1982 Soybeans	05.77	00.98	05.16	08.05	09.15
1983 Soybeans	16.69	01.54	07.13	25.87	28.99
1984 Soybeans	14.58	01.89	08.55	20.95	26.85
1982 Wheat	10.88	03.52	08.35	13.74	15.06
1983 Wheat	12.88	08.43	13.33	14.65	13.33
1984 Wheat	04.01	02.15	05.40	05.87	00.74
Average Value of Each Columm	10.96	06.18	09.16	13.33	14.04

TABLE IV

MEAN ABSOLUTE PERCENTAGE ERRORS (MAPE)
FOR FUTURES

	Entire Year	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
1982 Copper	07.31	04.56	01.88	11.18	13.23
1983 Copper	11.92	14.74	16.63	08.69	05.21
1984 Copper	08.00	06.08	01.70	10.65	14.79
1982 Corn	10.80	01.31	00.72	15.24	21.50
1983 Corn	21.12	18.14	18.65	24.86	19.08
1984 Corn	06.21	03.92	01.09	05.40	15.23
1982 Cotton	10.40	07.60	05.22	03.68	17.74
1983 Cotton	03.08	00.20	00.79	02.35	06.03
1984 Cotton	10.04	02.83	02.63	15.39	14.16
1982 Heating Oil	06.57	08.53	02.78	07.98	07.18
1983 Heating Oil	08.79	10.69	05.94	10.40	08.11
1984 Heating Oil	04.72	02.65	09.61	04.10	02.31
1982 Hogs	20.26	12.78	20.13	24.59	19.78
1983 Hogs	12.59	02.30	16.04	13.92	12.96
1984 Hogs	06.30	09.79	05.72	01.58	09.85
1982 Oats	11.26	04.17	07.29	14.48	15.87
1983 Oats	05.82	02.30	02.05	09.55	05.67
1984 Oats	01.94	00.53	04.19	02.48	00.00
1982 Soybeans	09.65	02.38	02.25	14.69	16.45
1983 Soybeans	16.72	03.51	07.22	24.97	27.90
1984 Soybeans	16.60	05.34	00.18	28.55	19.69
1982 Wheat	23.19	09.05	16.84	27.03	35.99
1983 Wheat	03.43	01.56	04.65	03.44	04.08
1984 Wheat	02.16	01.82	04.19	01.74	01.31
Average Value of Each Column	09.95	05.70	06.60	12.00	13.09

difference also tracks for each of the average quarterly MAPE's.

Twelve, or one half of the twenty-four yearly commodities analyzed, were more accurately predicted using the Box-Jenkins method, while the other half favored the futures market as a forecast. Table V lists the respective commodity and year under the appropriate method producing the lesser MAPE. Of note is the fact that the Box-Jenkins method proved more accurate, on a yearly average, than the futures market all three years for copper and soybeans. On the other side, the price of oats was more accurately forecasted in all three years by the futures market.

It is obvious that both methods result in wide variances. Absolute percentage errors have a range from as low as 0.0% for the December 1984 oats futures forecast, to as high as 36.09% for the September 1982 oats model forecast. Table VI breaks down the total of all 157 monthly observations showing which ones are more accurately forecast using the ARIMA models and which ones the futures market. The futures market was more accurate 56 percent of the time as compared to 44 percent for the ARIMA models.

Besides determining the absolute accuracy of the forecasts, the research attempts to show if a more profitable trading rule can be established through the use of ARIMA forecasting models. In order to investigate this question the following approach was implemented.

TABLE V

MINIMUM MAPE OVER A YEARLY BASIS

Box-Jenkins	Futures
1982 Copper	1983 Corn
1983 Copper	1984 Corn
1984 Copper	1983 Cotton
1982 Corn	1984 Cotton
1982 Cotton	1983 Heating Oil
1982 Heating Oil	1984 Heating Oil
1983 Hogs	1982 Hogs
1984 Hogs	1982 Oats
1982 Soybeans	1983 Oats
1983 Soybeans	1984 Oats
1984 Soybeans	1983 Wheat
1982 Wheat	1984 Wheat

TABLE VI

RESULTS OF THE TOTAL MONTHLY OBSERVATIONS

Forecast APE less than Futures APE	=	69	44%
Futures APE less than Forecast APE	=	88	56%
Total Number of Monthly Observations	=	157	100%

First a policy of buying commodities at the beginning of the year through the use of futures was applied. Buying the commodities with futures contracts insured prices at the value of the futures contract. By comparing the actual price during the month of delivery to the futures price, either a gain or loss could be determined. For example, if the July copper future sold for 78.75 cents per pound on January 1 and the actual cash price in July was 71.78 cents per pound, buying the futures contract resulted in a loss of 6.97 cents/lb. This is because had the futures not been purchased we would have been able to buy the copper at the lower cash price.

It is necessary to point out that the study will not pursue the endless number of possible hedging strategies which could also be incorporated into a buying policy. The gain or loss for each month was determined and totalled for the year. The net gain or loss for each commodity over the three years was calculated. The next step was to use the following trading rule. If the ARIMA Model forecast price was less than the futures price, do not buy futures but rather wait and purchase the commodity at the cash price in the delivery month. Again the gain or loss for each month and commodity were amassed and a net figure for each commodity was calculated. The results are presented in Table VII. The percentage gain/(loss) column shows how the

TABLE VII

RESULTS OF BUYING FUTURES

Gain/(Loss)	Always Buy Futures	Net For 3 Years	Buy Futures When Less Than Forecast	Net For 3 Years	Difference Gain/(Loss)	Percentage (Gain Loss)
Copper (cents/lb)						
1982	(13.38)		(3.7)			
1983	60.23	38.20	63.9	68.67	30.47	79.8%
1984	(8.65)		8.47			
Corn (cents/bu)						
1982	(131.75)		0			
1983	350.5	164.25	54.25	(5.25)	(169.50)	(103.2%)
1984	(54.5)		(59.50)			
Cotton (cents/lb)						
1982	(31.16)		0			
1983	10.00	(50.18)	0	(17.88)	32.30	64.4%
1984	(29.02)		(17.88)			
Heating Oil (cents/10 gal)						
1982	742.70		742.70			
1983	951.80	2057.70	951.80	2057.70	0	0%
1984	363.20		363.20			
Hogs ($/100 lb)						
1982	81.53		17.53			
1983	(37.80)	24.36	0	12.50	(11.86)	(48.7%)
1984	(19.37)		(5.03)			

TABLE VII (CONTINUED)

Oats (cents/bu)						
1982	(46.50)		(55.50)			
1983	(1.25)	(47.50)	0	(55.25)	(7.75)	(16.3%)
1984	0.25		0.25			
Soybeans (cents/bu)						
1982	(317.5)		19.5			
1983	945.50	(122.25)	86.75	(13.25)	109	89.2%
1984	(750.25)		(119.50)			
Wheat (cents/bu)						
1982	(382.25)		0			
1983	32.00	(388.00)	0	(33.00)	355	91.5%
1984	(37.75)		(33.00)			
Net Average Gain						19.6%

trading rule, incorporating the ARIMA models, compared to the policy of always buying commodity futures. Heating oil showed no difference because the futures price for all months during the three year period was less than the ARIMA forecasts. Of the remaining seven commodities, four of them showed significant gains with an average percentage gain of 81.2 porcent. While three of the commodities showed an average percentage loss of 56.1 percent. All eight commodities for the three year period showed a net average percentage gain of 19.6% by incorporating the ARIMA forecast prices in the determination of whether to buy futures or not.

The ARIMA model building technique attempts to identify the inherent pattern underlying the historical data. If the model changes parameters frequently, this is an indication of instability in the process and the model will be less reliable in forecasting futures prices. This is evidenced by the corn and oat commodities. Oats had three different models and corn had two for the three years analyzed. Both commodities were less accurate in forecasting futures prices using ARIMA models after they changed, than the futures market. In addition, both commodities had increased procurement costs when applying the buying rule over that of the "buy futures only" policy. This fact should act as an indicator to the analyst that the ARIMA model should not be relied upon when it changes parameters.

V. SUMMARY AND CONCLUSIONS

A. SUMMARY

The intent of this study was, first, to determine whether or not time series analysis, in particular Box-Jenkins ARIMA modeling, could be used to accurately forecast intermediate future commodity prices and, second, to examine the performance of these ARIMA models compared to the market forecasts, which were reflected in the commodities futures prices.

Through the iterative Box-Jenkins methodology and the use of the Minitab Statistical software on the IBM 3033 series mainframe computer, ARIMA models were developed using historical commodity prices. ARIMA models were developed for each of the eight commodities and used to forecast monthly prices for 1982, 1983 and 1984. The forecasts were for one year of prices and were updated at the completion of the year to reflect the most current price inputs. Futures prices were also collected at the end of the calendar year and used as the market's forecast, for the next year, for months when contracts were traded.

The accuracy of both the ARIMA forecasts and the futures contracts or market forecast were evaluated using Absolute Percentage Error (APE) and Mean Absolute Percentage Error

(MAPE) values. It was found that the yearly average MAPE for all 24 commodity-years were nearly equal for the futures and ARIMA forecasts with only a 1.01 percent difference, which was statistically insignificant. The forecast periods were also analyzed by the quarter. The results were as expected, with the accuracy of the forecast declining for the more distant forecasts. On the average, the futures market showed evidence of being more accurate, but only slightly, and statistically it is concluded that they are equally accurate.

Finally, the last objective of this research was to determine if the ARIMA forecast models could be used to increase profits or reduct costs from trading in the commodity market. A trading rule was adopted as follows: if a futures price was greater than the ARIMA forecast price, then do not purchase the futures contract, but rather wait until the delivery month and pay cash prices. This policy resulted in an average percentage gain of 19.6 percent over the "buying exclusively futures" policy, gain being a reduction in purchase costs.

B. CONCLUSIONS

The Box and Jenkins method of time series analysis can be used to forecast commodity prices relatively accurately. The results of this study showed an average mean absolute percentage error of 10.96 percent for ARIMA forecasts.

Comparison of the accuracy of ARIMA forecasts and the market forecast or futures reveals that statistically they are equally accurate.

The results of this study also show that the commodities market is at best weakly efficient. When incorporating the use of ARIMA model forecasts with market forecasts it was shown that forecast results could be improved and on the average a net profit in the form of reduced procurement costs could be realized. This tends to reinforce many of the studies in the literature which support the theory of an inefficient commodities market.

APPENDIX

COMPUTER FORECAST RESULTS

TABLE VIII

1982 COPPER

FORECAST FOR 1982 AVERAGE PRICE OF ELECTROLYTIC (WIREBAR) COPPER IN CENTS PER POUND:

				ABSOLUTE PERCENTAGE ERROR	
MONTH	FORECAST	ACTUAL	FUTURES	FORECAST	FUTURES
JAN	80.695	79.42	73.90	01.61	06.95
FEB	80.695	79.35	74.80	01.70	05.73
MAR	80.695	76.45	75.70	05.55	00.98
APR	80.695	76.99	--	--	--
MAY	80.695	78.88	77.30	02.43	01.88
JUN	80.695	71.43	--	--	--
JUL	80.695	71.78	78.75	12.42	09.71
AUG	80.695	71.84	--	--	--
SEP	80.695	71.37	80.40	13.07	12.65
OCT	80.695	71.92	--	--	--
NOV	80.695	72.28	--	--	--
DEC	80.695	73.17	82.85	10.28	13.23

ARIMA 0 1 1 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	MA 1	-0.2598	0.0847	-3.07

DIFFERENCING:
1 REGULAR

NO. OF OBSERVATIONS:
ORIGINAL SERIES 132 AFTER DIFFERENCING 131

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 06.72
ENTIRE YEAR FOR FUTURES = 07.31

TABLE IX

1983 COPPER

FORECAST FOR 1983 AVERAGE PRICE OF ELECTROLYTIC (WIREBAR) COPPER IN CENTS PER POUND:

MONTH	FORECAST	ACTUAL	FUTURES	ABSOLUTE PERCENTAGE ERROR FORECAST	ABSOLUTE PERCENTAGE ERROR FUTURES
JAN	73.378	79.03	68.35	07.15	13.51
FEB	73.378	82.72	69.00	11.29	16.59
MAR	73.378	81.09	69.65	09.51	14.11
APR	73.378	82.44	--	--	--
MAY	73.378	84.80	70.70	13.47	16.63
JUN	73.378	80.90	--	--	--
JUL	73.378	81.81	71.80	10.31	12.24
AUG	73.378	79.80	--	--	--
SEP	73.378	76.75	72.80	04.39	05.15
OCT	73.378	71.58	--	--	--
NOV	73.378	68.64	--	--	--
DEC	73.378	70.43	74.10	04.19	05.21

ARIMA 0 1 1 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	MA 1	-0.2482	0.0813	-3.05

DIFFERENCING:
1 REGULAR

NO. OF OBSERVATIONS:
ORIGINAL SERIES 144 AFTER DIFFERENCING 143

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 08.62
ENTIRE YEAR FOR FUTURES = 11.92

TABLE X

1984 COPPER

FORECAST FOR 1984 AVERAGE PRICE OF ELECTROLYTIC (WIREBAR) COPPER IN CENTS PER POUND:

MONTH	FORECAST	ACTUAL	FUTURES	ABSOLUTE PERCENTAGE ERROR FORECAST	ABSOLUTE PERCENTAGE ERROR FUTURES
JAN	70.998	68.08	65.75	04.29	03.42
FEB	70.998	69.95	66.35	01.50	05.15
MAR	70.998	74.18	67.00	04.29	09.68
APR	70.998	74.63	--	--	--
MAY	70.998	69.48	68.30	02.18	01.70
JUN	70.998	67.01	--	--	--
JUL	70.998	63.83	69.65	11.23	09.12
AUG	70.998	64.19	--	--	--
SEP	70.998	63.29	71.00	12.18	12.18
OCT	70.998	61.72	--	--	--
NOV	70.998	65.57	--	--	--
DEC	70.998	63.64	73.05	11.56	14.79

ARIMA 0 1 1 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	MA 1	-0.2534	0.0780	-3.25

DIFFERENCING:
1 REGULAR

NO. OF OBSERVATIONS:
ORIGINAL SERIES 156 AFTER DIFFERENCING 155

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 06.75
ENTIRE YEAR FOR FUTURES = 08.00

TABLE XI

1982 CORN

FORECAST FOR 1982 AVERAGE CASH PRICE OF CORN, NO. 2, YELLOW AT CHICAGO IN CENTS PER BUSHEL:

				ABSOLUTE PERCENTAGE ERROR	
MONTH	FORECAST	ACTUAL	FUTURES	FORECAST	FUTURES
JAN	247.061	263	--	--	--
FEB	247.982	263	--	--	--
MAR	247.585	267	270.5	07.27	01.31
APR	247.439	278	--	--	--
MAY	247.385	279	281	11.33	00.72
JUN	247.366	277	--	--	--
JUL	247.358	267	286.75	07.36	07.40
AUG	247.355	241	--	--	--
SEP	247.354	235	289.25	05.26	23.09
OCT	247.353	213	--	--	--
NOV	247.352	238	--	--	--
DEC	247.352	243	295.25	01.79	21.50

ARIMA 1 1 0 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	AR 1	0.3673	0.0807	4.55

DIFFERENCING:
1 REGULAR

NO. OF OBSERVATIONS:
ORIGINAL SERIES 135 AFTER DIFFERENCING 134

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 06.60
ENTIRE YEAR FOR FUTURES = 10.80

TABLE XII

1983 CORN

FORECAST FOR 1983 AVERAGE CASH PRICE OF CORN, NO. 2, YELLOW AT CHICAGO IN CENTS PER BUSHEL:

MONTH	FORECAST	ACTUAL	FUTURES	ABSOLUTE PERCENTAGE ERROR FORECAST	ABSOLUTE PERCENTAGE ERROR FUTURES
JAN	251.722	253	--	--	--
FEB	251.678	274	--	--	--
MAR	251.678	299	244.75	15.83	18.14
APR	251.678	312	--	--	--
MAY	251.678	311	253	19.07	18.65
JUN	251.678	329	--	--	--
JUL	251.678	366	259.25	25.10	22.84
AUG	251.678	367	--	--	--
SEP	251.678	361	264	30.28	26.87
OCT	251.678	349	--	--	--
NOV	251.678	350	--	--	--
DEC	251.678	338	273.5	25.54	19.08

ARIMA 0 1 2 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	MA 1	-0.3419	0.0797	-4.29
2	MA 2	-0.2965	0.0809	-3.66

DIFFERENCING:
1 REGULAR

NO. OF OBSERVATIONS:
ORIGINAL SERIES 147 AFTER DIFFERENCING 146

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 23.16
ENTIRE YEAR FOR FUTURES = 21.12

TABLE XIII

1984 CORN

FORECAST FOR 1984 AVERAGE CASH PRICE OF CORN, NO. 2, YELLOW AT CHICAGO IN CENTS PER BUSHEL:

				ABSOLUTE PERCENTAGE ERROR	
MONTH	FORECAST	ACTUAL	FUTURES	FORECAST	FUTURES
JAN	337.129	329	--	--	--
FEB	333.841	328	--	--	--
MAR	333.841	351	337.25	04.89	03.92
APR	333.841	345	--	--	--
MAY	333.841	344	340.25	02.95	01.09
JUN	333.841	345	--	--	--
JUL	333.841	328	340.5	01.78	03.81
AUG	333.841	316	--	--	--
SEP	333.841	293	313.5	13.94	07.00
OCT	333.841	266	--	--	--
NOV	333.841	262	--	--	--
DEC	333.841	256	295	30.41	15.23

ARIMA 0 1 2 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	MA 1	-0.3371	0.0767	-4.39
2	MA 2	-0.2911	0.0772	-3.77

DIFFERENCING:
1 REGULAR

NO. OF OBSERVATIONS:
ORIGINAL SERIES 159 AFTER DIFFERENCING 158

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 10.79
ENTIRE YEAR FOR FUTURES = 06.21

TABLE XIV

1982 COTTON

FORECAST FOR 1982 AVERAGE PRICE OF STRICT LOW MIDDLING, 1-1/16", COTTON AT DESIGNATED U.S. MARKETS IN CENTS PER POUND:

MONTH	FORECAST	ACTUAL	FUTURES	ABSOLUTE PERCENTAGE ERROR FORECAST	ABSOLUTE PERCENTAGE ERROR FUTURES
JAN	55.0022	57.82	--	--	--
FEB	55.2344	57.26	--	--	--
MAR	55.8702	59.73	64.27	06.46	07.60
APR	56.0728	62.03	--	--	--
MAY	56.3220	62.44	65.70	09.80	05.22
JUN	55.5017	61.10	--	--	--
JUL	56.7294	64.96	67.35	12.67	03.68
AUG	57.0135	60.38	--	--	--
SEP	56.7154	58.98	--	--	--
OCT	56.7753	58.58	69.00	03.08	17.79
NOV	56.0198	58.20	--	--	--
DEC	56.6279	59.65	70.20	05.07	17.69

ARIMA 0 1 1. 0 1 1, 12 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	MA 1	-0.6129	0.0715	-8.57
2	SMA 12	0.8640	0.0780	11.07

DIFFERENCING:
1 REGULAR 1 SEASONAL DIFFERENCES OF ORDER 12

NO. OF OBSERVATIONS:
ORIGINAL SERIES 137 AFTER DIFFERENCING 124

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 07.42
ENTIRE YEAR FOR FUTURES = 10.40

TABLE XV

1983 COTTON

FORECAST FOR 1983 AVERAGE PRICE OF STRICT LOW MIDDLING, 1-1/16", COTTON AT DESIGNATED U.S. MARKETS IN CENTS PER POUND:

MONTH	FORECAST	ACTUAL	FUTURES	ABSOLUTE PERCENTAGE ERROR FORECAST	ABSOLUTE PERCENTAGE ERROR FUTURES
JAN	60.1316	60.16	--	--	--
FEB	60.5595	61.72	--	--	--
MAR	60.4757	66.05	65.92	08.44	00.20
APR	60.9359	65.33	--	--	--
MAY	61.0631	66.88	67.41	08.70	00.79
JUN	60.4990	70.74	--	--	--
JUL	61.5131	70.27	68.62	12.46	02.35
AUG	60.5419	72.93	--	--	--
SEP	59.8521	71.68	--	--	--
OCT	59.8687	72.01	67.90	16.86	05.71
NOV	58.9134	73.41	--	--	--
DEC	59.6228	73.04	68.40	18.37	06.35

ARIMA 0 1 1, 0 1 1, 12 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	MA 1	-0.5393	0.0730	-7.38
2	SMA 12	0.0921	0.0709	12.58

DIFFERENCING:
1 REGULAR 1 SEASONAL DIFFERENCES OF ORDER 12

NO. OF OBSERVATIONS:
ORIGINAL SERIES 149 AFTER DIFFERENCING 136

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 12.97
ENTIRE YEAR FOR FUTURES = 03.08

TABLE XVI

1984 COTTON

FORECAST FOR 1984 AVERAGE PRICE OF STRICT LOW MIDDLING, 1-1/16", COTTON AT DESIGNATED U.S. MARKETS IN CENTS PER POUND:

				ABSOLUTE PERCENTAGE ERROR	
MONTH	FORECAST	ACTUAL	FUTURES	FORECAST	FUTURES
JAN	73.123	70.55	--	--	--
FEB	73.739	71.06	--	--	--
MAR	74.405	74.99	77.11	00.78	02.83
APR	74.924	76.27	--	--	--
MAY	75.405	80.54	78.42	06.38	02.63
JUN	75.245	76.07	--	--	--
JUL	76.561	67.96	79.10	12.66	16.39
AUG	76.191	63.11	--	--	--
SEP	75.669	60.72	--	--	--
OCT	75.703	68.83	74.44	09.99	08.15
NOV	75.137	60.44	--	--	--
DEC	75.580	60.83	73.10	24.25	20.17

ARIMA 0 1 1, 0 1 1, 12 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	MA 1	-0.4917	0.0720	-6.83
2	SMA 12	0.8949	0.0643	13.92

DIFFERENCING:
1 REGULAR 1 SEASONAL DIFFERENCES OF ORDER 12

NO. OF OBSERVATIONS:
ORIGINAL SERIES 161 AFTER DIFFERENCING 148

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 10.81
ENTIRE YEAR FOR FUTURES = 10.04

TABLE XVII

1982 HEATING OIL NO. 2

FORECAST FOR 1982 AVERAGE PRICE OF DISTILLATE (MIDDLE) NO. 2 FUEL OIL IN CENTS PER 10 GALLONS:

				ABSOLUTE PERCENTAGE ERROR	
MONTH	FORECAST	ACTUAL	FUTURES	FORECAST	FUTURES
JAN	1064.94	1067.80	971.0	00.27	09.07
FEB	1066.38	1058.20	967.0	00.77	08.62
MAR	1066.85	1029.30	947.9	03.65	07.91
APR	1067.01	953.60	931.8	11.89	02.29
MAY	1067.06	928.70	922.5	14.90	00.67
JUN	1067.08	974.60	922.0	09.49	05.40
JUL	1067.08	1024.00	924.0	04.21	09.77
AUG	1067.08	1022.20	930.0	04.39	09.02
SEP	1067.08	1001.70	950.0	06.53	05.16
OCT	1067.08	997.70	955.0	06.95	04.28
NOV	1067.08	1040.60	--	--	--
DEC	1067.08	1053.60	947.5	01.28	10.07

ARIMA 1 1 0 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	AR 1	0.3313	0.0918	3.61

DIFFERENCING:
1 REGULAR

NO. OF OBSERVATIONS:
ORIGINAL SERIES 108 AFTER DIFFERENCING 107

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 05.85
ENTIRE YEAR FOR FUTURES = 06.57

TABLE XVIII

1983 HEATING OIL NO. 2

FORECAST FOR 1983 AVERAGE PRICE OF DISTILLATE (MIDDLE) NO. 2 FUEL OIL IN CENTS PER 10 GALLONS:

				ABSOLUTE PERCENTAGE ERROR	
MONTH	FORECAST	ACTUAL	FUTURES	FORECAST	FUTURES
JAN	1058.12	985.30	828.1	07.39	15.95
FEB	1059.69	927.40	838.7	14.26	09.56
MAR	1060.23	874.20	816.8	21.28	06.57
APR	1060.42	813.40	795.9	30.37	02.15
MAY	1060.49	838.10	790.0	26.54	05.74
JUN	1060.51	879.40	792.0	20.59	09.94
JUL	1060.51	876.30	785.0	21.02	10.42
AUG	1060.52	883.00	790.0	20.10	10.53
SEP	1060.51	893.50	802.0	18.69	10.24
OCT	1060.51	911.40	820.0	16.36	10.03
NOV	1060.51	901.00	829.0	17.70	07.99
DEC	1060.51	891.30	835.0	18.98	06.32

ARIMA 1 1 0 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	AR 1	0.3476	0.0864	4.02

DIFFERENCING:
1 REGULAR

NO. OF OBSERVATIONS:
ORIGINAL SERIES 120 AFTER DIFFERENCING 119

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 19.44
ENTIRE YEAR FOR FUTURES = 08.79

TABLE XIX

1984 HEATING OIL NO. 2

FORECAST FOR 1984 AVERAGE PRICE OF DISTILLATE (MIDDLE) NO. 2 FUEL OIL IN CENTS PER 10 GALLONS:

MONTH	FORECAST	ACTUAL	FUTURES	ABSOLUTE PERCENTAGE ERROR FORECAST	FUTURES
JAN	887.62	870.60	842.4	01.96	03.24
FEB	886.23	867.00	826.5	02.22	04.67
MAR	885.70	792.60	793.0	11.75	00.05
APR	885.50	853.40	762.9	03.76	10.60
MAY	885.42	841.00	736.0	05.28	12.49
JUN	885.39	778.90	734.2	13.67	05.74
JUL	885.38	753.40	736.2	17.52	02.28
AUG	885.37	764.70	--	--	--
SEP	885.37	796.70	749.5	11.13	05.92
OCT	885.37	778.50	757.0	13.73	02.76
NOV	885.37	764.50	777.5	15.81	01.70
DEC	885.36	741.80	760.0	19.35	02.45

ARIMA 1 1 0 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	AR 1	0.3790	0.0812	4.67

DIFFERENCING:
1 REGULAR

NO. OF OBSERVATIONS:
ORIGINAL SERIES 132 AFTER DIFFERENCING 131

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 10.56
ENTIRE YEAR FOR FUTURES = 04.72

TABLE XX

1982 HOGS

FORECAST FOR 1982 AVERAGE WHOLESALE PRICE OF HOGS, AVERAGE (ALL WEIGHTS) AT SIOUX CITY IN DOLLARS PER 100 POUNDS:

MONTH	FORECAST	ACTUAL	FUTURES	ABSOLUTE PERCENTAGE ERROR FORECAST	ABSOLUTE PERCENTAGE ERROR FUTURES
JAN	38.2571	45.77	--	--	--
FEB	39.4804	49.70	43.35	20.56	12.78
MAR	37.0453	49.50	--	---	--
APR	36.0982	52.16	42.95	30.79	17.66
MAY	38.4902	58.35	--	--	--
JUN	42.0566	59.01	45.67	28.73	22.61
JUL	44.5720	59.70	46.90	25.34	21.44
AUG	46.4288	63.18	45.65	26.51	27.75
SEP	45.3817	63.12	--	--	--
OCT	44.0869	57.27	44.55	23.02	22.21
NOV	42.2378	53.90	--	--	--
DEC	43.2556	55.23	45.65	21.68	17.35

ARIMA 2 0 0, 0 1 1, 12 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	AR 1	1.3930	0.1184	11.77
2	AR 2	-0.5429	0.1145	-4.74
3	SMA 12	0.7903	0.1266	6.24

DIFFERENCING:
0 REGULAR 1 SEASONAL DIFFERENCE OF ORDER 12

NO. OF OBSERVATIONS:
ORIGINAL SERIES 72 AFTER DIFFERENCING 60

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 25.23
ENTIRE YEAR FOR FUTURES = 20.26

TABLE XXI

1983 HOGS

FORECAST FOR 1983 AVERAGE WHOLESALE PRICE OF HOGS, AVERAGE (ALL WEIGHTS) AT SIOUX CITY IN DOLLARS PER 100 POUNDS:

				ABSOLUTE PERCENTAGE ERROR	
MONTH	FORECAST	ACTUAL	FUTURES	FORECAST	FUTURES
JAN	55.6828	57.24	--	--	--
FEB	55.9400	57.78	56.45	03.18	02.30
MAR	51.7077	51.37	--	--	--
APR	49.3907	47.84	53.75	03.24	12.35
MAY	50.3828	47.40	--	--	--
JUN	51.6175	45.73	54.75	12.87	19.72
JUL	51.9710	45.81	54.95	13.45	19.95
AUG	52.5108	49.77	53.70	05.51	07.90
SEP	50.7195	46.05	--	--	--
OCT	47.7396	41.64	49.55	14.65	19.00
NOV	45.0495	38.81	--	--	--
DEC	45.8222	46.53	49.75	01.52	06.92

ARIMA 2 0 0, 0 1 1, 12 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	AR 1	1.3598	0.1127	12.06
2	AR 2	-0.4557	0.1118	-4.08
3	SMA 12	0.8162	0.1161	7.03

DIFFERENCING:
0 REGULAR 1 SEASONAL DIFFERENCE OF ORDER 12

NO. OF OBSERVATIONS:
ORIGINAL SERIES 84 AFTER DIFFERENCING 72

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 07.78
ENTIRE YEAR FOR FUTURES = 12.59

TABLE XXII

1984 HOGS

FORECAST FOR 1984 AVERAGE WHOLESALE PRICE OF HOGS, AVERAGE (ALL WEIGHTS) AT SIOUX CITY IN DOLLARS PER 100 POUNDS:

				ABSOLUTE PERCENTAGE ERROR	
MONTH	FORECAST	ACTUAL	FUTURES	FORECAST	FUTURES
JAN	50.8203	50.14	--	--	--
FEB	53.5541	46.68	51.25	14.73	09.79
MAR	50.5025	47.36	--	---	--
APR	48.9378	47.79	48.25	02.40	00.96
MAY	50.4306	47.72	--	--	--
JUN	50.8512	48.02	53.05	05.90	10.47
JUL	50.9632	54.05	53.37	05.71	01.26
AUG	52.0822	51.91	52.90	00.33	01.91
SEP	50.0257	47.04	--	--	--
OCT	46.4022	44.37	50.97	04.58	14.87
NOV	43.6018	48.43	--	--	--
DEC	45.6287	49.80	52.20	08.38	04.82

ARIMA 2 0 0, 0 1 1, 12 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	AR 1	1.3697	0.1035	13.24
2	AR 2	-0.4720	0.1015	-4.65
3	SMA 12	0.8569	0.0955	8.98

DIFFERENCING:
0 REGULAR 1 SEASONAL DIFFERENCE OF ORDER 12

NO. OF OBSERVATIONS:
ORIGINAL SERIES 96 AFTER DIFFERENCING 84

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 06.00
ENTIRE YEAR FOR FUTURES = 06.30

TABLE XXIII

1982 OATS

FORECAST FOR 1982 AVERAGE CASH PRICE OF NO. 2, EXTRA HEAVY WHITE OATS AT MINNEAPOLIS IN CENTS PER BUSHEL:

MONTH	FORECAST	ACTUAL	FUTURES	ABSOLUTE PERCENTAGE ERROR FORECAST	ABSOLUTE PERCENTAGE ERROR FUTURES
JAN	200.782	223	--	--	--
FEB	203.178	226	--	--	--
MAR	206.122	216	207	04.57	04.17
APR	206.217	221	--	--	--
MAY	205.484	216	200.25	04.87	07.29
JUN	205.283	212	--	--	--
JUL	205.423	187	192.25	09.85	02.81
AUG	205.508	153	--	--	--
SEP	205.493	151	190.5	36.09	26.16
OCT	205.467	151	--	--	--
NOV	205.465	167	--	--	--
DEC	205.471	167	193.5	23.04	15.87

ARIMA 2 1 0 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	AR 1	0.2412	0.0850	2.84
2	AR 2	-0.2567	0.0861	-2.98

DIFFERENCING:
1 REGULAR

NO. OF OBSERVATIONS:
ORIGINAL SERIES 138 AFTER DIFFERENCING 137

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 15.68
ENTIRE YEAR FOR FUTURES = 11.26

TABLE XXIV

1983 OATS

FORECAST FOR 1983 AVERAGE CASH PRICE OF NO. 2, EXTRA HEAVY WHITE OATS AT MINNEAPOLIS IN CENTS PER BUSHEL:

				ABSOLUTE PERCENTAGE ERROR	
MONTH	FORECAST	ACTUAL	FUTURES	FORECAST	FUTURES
JAN	165.799	167	--	--	--
FEB	165.799	163	--	--	--
MAR	165.799	163	166.75	01.72	02.30
APR	165.799	173	--	--	--
MAY	165.799	171	174.5	03.04	02.05
JUN	165.799	167	--	--	--
JUL	165.799	160	179	03.62	11.88
AUG	165.799	179	--	--	--
SEP	165.799	194	180	14.54	07.22
OCT	165.799	200	--	--	--
NOV	165.799	197	--	--	--
DEC	165.799	194	183	14.54	05.67

ARIMA 0 1 1 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	MA 1	-0.2706	0.0794	-3.41

DIFFERENCING:
1 REGULAR

NO. OF OBSERVATIONS:
ORIGINAL SERIES 150 AFTER DIFFERENCING 149

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 07.49
ENTIRE YEAR FOR FUTURES = 05.82

TABLE XXV

1984 OATS

FORECAST FOR 1984 AVERAGE CASH PRICE OF NO. 2, EXTRA HEAVY WHITE OATS AT MINNEAPOLIS IN CENTS PER BUSHEL:

MONTH	FORECAST	ACTUAL	FUTURES	ABSOLUTE PERCENTAGE ERROR FORECAST	ABSOLUTE PERCENTAGE ERROR FUTURES
JAN	193.846	198	--	--	--
FEB	195.623	182	--	--	--
MAR	195.569	187	186	04.58	00.53
APR	195.801	190	--	--	--
MAY	197.578	197	188.75	00.29	04.19
JUN	197.523	192	--	--	--
JUL	197.756	184	188	07.48	02.17
AUG	199.532	177	--	--	--
SEP	199.478	179	184	11.44	02.79
OCT	199.710	184	--	--	--
NOV	201.486	192	--	--	--
DEC	201.432	187	187	07.72	00.00

ARIMA 0 1 1, 0 1 1, 3 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	MA 1	-0.2712	0.0772	-3.51
2	SMA 3	0.9594	0.0351	27.37

DIFFERENCING:
1 REGULAR 1 SEASONAL DIFFERENCE OF ORDER 3

NO. OF OBSERVATIONS:
ORIGINAL SERIES 162 AFTER DIFFERENCING 158

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 06.30
ENTIRE YEAR FOR FUTURES = 01.94

TABLE XXVI

1982 SOYBEAN

FORECAST FOR 1982 AVERAGE CASH PRICE OF NO. 1 YELLOW SOYBEAN AT ILLINOIS PROCESSOR IN CENTS PER BUSHEL:

MONTH	FORECAST	ACTUAL	FUTURES	ABSOLUTE PERCENTAGE ERROR FORECAST	ABSOLUTE PERCENTAGE ERROR FUTURES
JAN	623.91	630	610.5	00.97	03.10
FEB	622.15	624	--	--	--
MAR	622.15	616	626.25	01.00	01.66
APR	622.15	642	--	--	--
MAY	622.15	656	641.25	05.16	02.25
JUN	622.15	631	--	--	--
JUL	622.15	620	656.75	00.35	05.93
AUG	622.15	573	660	08.58	15.18
SEP	622.15	540	664	15.21	22.96
OCT	622.15	526	--	--	--
NOV	622.15	570	663.75	09.15	16.45
DEC	622.15	573	--	--	--

ARIMA 0 1 2 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	MA 1	-0.1745	C.0847	-2.06
2	MA 2	-0.2335	0.0847	-2.76

DIFFERENCING:
1 REGULAR

NO. OF OBSERVATIONS:
ORIGINAL SERIES 135 AFTER DIFFERENCING 134

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 05.77
ENTIRE YEAR FOR FUTURES = 09.65

TABLE XXVII

1983 SOYBEAN

FORECAST FOR 1983 AVERAGE CASH PRICE OF NO. 1 YELLOW SOYBEAN AT ILLINOIS PROCESSOR IN CENTS PER BUSHEL:

MONTH	FORECAST	ACTUAL	FUTURES	ABSOLUTE PERCENTAGE ERROR FORECAST	ABSOLUTE PERCENTAGE ERROR FUTURES
JAN	583.60	581	564.25	00.45	02.88
FEB	582.30	586	--	--	--
MAR	582.30	598	573.25	02.63	04.14
APR	582.30	635	--	--	--
MAY	582.30	627	581.75	07.13	07.22
JUN	582.30	606	--	--	--
JUL	582.30	659	589.5	11.64	10.55
AUG	582.30	846	590.5	31.17	30.20
SEP	582.30	893	588	34.79	34.15
OCT	582.30	846	--	--	--
NOV	582.30	820	591.25	28.99	27.90
DEC	582.30	777	--	--	--

ARIMA 0 1 2 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	MA 1	-0.1762	0.0811	-2.17
2	MA 2	-0.2324	0.0813	-2.86

DIFFERENCING:
1 REGULAR

NO. OF OBSERVATIONS:
ORIGINAL SERIES 147 AFTER DIFFERENCING 146

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 16.69
ENTIRE YEAR FOR FUTURES = 16.72

TABLE XXVIII

1984 SOYBEAN

FORECAST FOR 1984 AVERAGE CASH PRICE OF NO. 1 YELLOW SOYBEAN AT ILLINOIS PROCESSOR IN CENTS PER BUSHEL:

				ABSOLUTE PERCENTAGE ERROR	
MONTH	FORECAST	ACTUAL	FUTURES	FORECAST	FUTURES
JAN	769.99	767	814.5	00.39	06.19
FEB	769.99	737	--	--	--
MAR	769.99	797	832.75	03.39	04.49
APR	769.99	798	--	--	--
MAY	769.99	842	843.5	08.55	00.18
JUN	769.99	773	--	--	--
JUL	769.99	665	849	15.79	27.67
AUG	769.99	645	835.5	19.38	29.53
SEP	769.99	603	774.5	27.69	28.44
OCT	769.99	605	--	--	--
NOV	769.99	607	726.5	26.85	19.69
DEC	769.99	588	--	--	--

ARIMA 0 1 2 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	MA 1	-0.2031	0.0787	-2.58
2	MA 2	-0.1842	0.0787	-2.34

DIFFERENCING:
1 REGULAR

NO. OF OBSERVATIONS:
ORIGINAL SERIES 159 AFTER DIFFERENCING 158

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 14.58
ENTIRE YEAR FOR FUTURES = 16.60

TABLE XXIX

1982 WHEAT

FORECAST FOR 1982 AVERAGE PRICE OF NO. 2 SOFT RED WINTER (30 DAYS) WHEAT AT CHICAGO IN CENTS PER BUSHEL:

MONTH	FORECAST	ACTUAL	FUTURES	ABSOLUTE PERCENTAGE ERROR FORECAST	ABSOLUTE PERCENTAGE ERROR FUTURES
JAN	371.642	377	--	--	--
FEB	371.642	357	--	--	--
MAR	371.642	359	391.5	03.52	09.05
APR	371.642	370	--	--	--
MAY	371.642	343	400.75	08.35	16.84
JUN	371.642	331	--	--	--
JUL	371.642	336	408	10.61	21.43
AUG	371.642	335	--	--	--
SEP	371.642	318	421.75	16.87	32.63
OCT	371.642	298	--	--	--
NOV	371.642	333	--	--	--
DEC	371.642	323	439.25	15.06	35.99

ARIMA 0 1 1 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	MA 1	-0.5177	0.0736	-7.04

DIFFERENCING:
1 REGULAR

NO. OF OBSERVATIONS:
ORIGINAL SERIES 139 AFTER DIFFERENCING 138

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 10.88
ENTIRE YEAR FOR FUTURES = 23.19

TABLE XXX

1983 WHEAT

FORECAST FOR 1983 AVERAGE PRICE OF NO. 2 SOFT RED WINTER (30 DAYS) WHEAT AT CHICAGO IN CENTS PER BUSHEL:

				ABSOLUTE PERCENTAGE ERROR	
MONTH	FORECAST	ACTUAL	FUTURES	FORECAST	FUTURES
JAN	307.677	332	--	--	--
FEB	307.677	340	--	--	--
MAR	307.677	336	330.75	08.43	01.56
APR	307.677	351	--	--	--
MAY	307.677	355	338.5	13.33	04.65
JUN	307.677	353	--	--	--
JUL	307.677	359	343.25	14.30	04.39
AUG	307.677	371	--	--	--
SEP	307.677	362	353	15.01	02.49
OCT	307.677	356	--	--	--
NOV	307.677	342	--	--	--
DEC	307.677	355	369.5	13.33	04.08

ARIMA 0 1 1 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	MA 1	-0.5009	0.0719	-6.97

DIFFERENCING:
1 REGULAR

NO. OF OBSERVATIONS:
ORIGINAL SERIES 151 AFTER DIFFERENCING 150

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 12.88
ENTIRE YEAR FOR FUTURES = 03.43

TABLE XXXI

1984 WHEAT

FORECAST FOR 1984 AVERAGE PRICE OF NO. 2 SOFT RED WINTER (30 DAYS) WHEAT AT CHICAGO IN CENTS PER BUSHEL:

				ABSOLUTE PERCENTAGE ERROR	
MONTH	FORECAST	ACTUAL	FUTURES	FORECAST	FUTURES
JAN	364.688	347	--	--	--
FEB	364.688	334	--	--	--
MAR	364.688	357	363.5	02.15	01.82
APR	364.688	365	--	--	--
MAY	364.688	346	360.5	05.40	04.19
JUN	364.688	341	--	--	--
JUL	364.688	341	348	06.95	02.05
AUG	364.688	346	--	--	--
SEP	364.688	348	353	04.80	01.44
OCT	364.688	356	--	--	--
NOV	364.688	368	--	--	--
DEC	364.688	362	366.75	00.74	01.31

ARIMA 0 1 1 USED

FINAL ESTIMATES OF PARAMETERS:

NUMBER	TYPE	ESTIMATE	ST. DEV.	T-RATIO
1	MA 1	-0.4862	0.0691	-7.03

DIFFERENCING:
1 REGULAR

NO OF OBSERVATIONS:
ORIGINAL SERIES 163 AFTER DIFFERENCING 162

MEAN ABSOLUTE PERCENTAGE ERROR:
ENTIRE YEAR FOR FORECAST = 04.01
ENTIRE YEAR FOR FUTURES = 02.16

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